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Characterisation of urban spaces from space: going beyond the urban versus rural dichotomy

Surveys of human health and welfare routinely draw a distinction between people living in urban and rural areas because censuses, from which surveys draw their sampling frames, distinguish between rural and urban residence. However, large areas of cities in low-income and middle-income countries (LMICs) are classified as informal settlements or slums.[1,2] These sites are invisible in censuses and hence in sampling frames. We argue first that all countries that harbour slums should follow the example of the few countries that distinguish slums from non-slum areas in their censuses. Second, we argue that satellite images are likely to be useful in making this distinction in a reproducible way, and third, through linking satellite data to other routinely-collected data, derivation of a fine-grained analysis of city precincts might be possible.

The argument for slum demarcation within cities is an extension of the argument to distinguish between urban and rural localities, which have large differences in health and its determinants. Although socioeconomic variables associated with health outcomes are routinely collected in surveys, space is also salient, net of the effects of wealth. For example, a study in the USA shows that people who are economically impoverished in low-income cities, such as Detroit, MI, have worse health outcomes than people with equally constrained financial circumstances in high-income cities, such as San Francisco, CA.[3] Such neighbourhood effects appear large in the slums of LMICs, where the intimately shared environment entails shared risks of the infectious, geographical, and social determinants of health.[2] Therefore, strong arguments exist that slum areas should be distinguished from other city spaces in land use maps and censuses,[4,5] and hence the surveys that use censuses to derive their sampling frames. Few countries (Bangladesh, India, Egypt, and Brazil) make this distinction in their censuses. We believe that all countries with slums should follow their lead. However, demarcation of slums from observations made on the ground is difficult for a census surveyor because of the unstructured and continually evolving nature of urban sprawl. Satellite images based on features such as building footprints and lane networks can characterise slum areas in a way that is consistent across time and place and not subject to variability across observers.[6]

Censuses identify individuals, whereas satellites can only observe structures. For that reason, satellites cannot replace censuses. However, satellite images are available inexpensively, whereas censuses are expensive and hence can only be done every 10 years. Satellite images have been used to map slums and these maps can be used to estimate population densities[7] and isochrones (areas with homogeneous travel times to destinations, such as places of employment).[8,9] We think this process could be greatly improved and automated using large-scale machine learning. In view of the diversity of slums, there will be also a need for so called ground-truthing based on data collected by local people; a citizen–science approach.[6,8]

Health and wealth in slums is highly heterogenous.[10] Therefore, an argument exists to go beyond a slum versus non-slum dichotomy and produce a fine-grained assessment of urban environments through use of features identifiable from space (paving of lanes, density of structures, and even open sewers) and combining these with data from other sources. For example, anonymous data collected via mobile phones could be used to gain further information on population density and social networks across a city—a method that has already provided more sensitive indicators of impending epidemics than have data collected from health facilities.[11] Images taken close to the ground could provide further information to buttress satellite data. Therefore, we are not necessarily limited to satellite imagery in classification systems. As these methods evolve, other types of data that can be harvested systematically could be used. The fine-grained mapping of city areas would have many uses: enrich census data, guide sampling for epidemiological studies, audit the comprehensiveness of censuses, track urban development within and across nations, and a local planning tool.

Limitations exist to what can be learned from space—ie, water quality and tenure cannot be assessed from space. The purpose of classification is not to do in-depth studies, but to guide them and their interpretation. The classification system's purpose is to help to interpret survey data, such as Demographic Health Survey data, by relating human health and wellbeing to spatial characteristics. Spatial data can determine the areas where it would be most important to do in-depth studies, and guide sampling frames within these areas.[12]

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1 UN-Habitat. Urbanization and development: emerging futures. Nairobi: UN-Habitat, 2016.
2 Ezeh A, Oyebode O, Satterthwaite D, et al. The history, geography, and sociology of slums and the health problems of people who live in slums. *Lancet* 2017; **389:** 547–58.
3 Chetty R, Stepner M, Abraham S, et al. The association between income and life expectancy in the United States, 2001–2014. *JAMA* 2016; **315:** 1750–66.
4 Lilford RJ, Oyebode O, Satterthwaite D, et al. Improving the health and welfare of people who live in slums. *Lancet* 2017; **389:** 559–70.
5 Lucci P, Bhatkal T, Khan A. Are we underestimating urban poverty? London: Overseas Development Institute, 2016.
6 Kuffer M, Pfeffer K, Sliuzas R. Slums from space—15 years of slum mapping using remote sensing. *Remote Sens* 2016; **8:** 455.
7 Albuquerque J, Herfort B, Eckle M. The tasks of the crowd: a typology of tasks in geographic information crowdsourcing and a case study in humanitarian mapping. *Remote Sens* 2016; **8:** 859.
8 Lung T, Lübker T, Ngochoch JK, Schaab G. Human population distribution modelling at regional level using very high resolution satellite imagery. *Appl Geogr* 2013; **41:** 36–45.
9 Frew R, Higgs G, Harding J, Langford M. Investigating geospatial data usability from a health geography perspective using sensitivity analysis: the example of potential accessibility to primary healthcare. *J Transp Health* 2017; **6:** 128–42.
10 Harpham T. Urban health in developing countries: what do we know and where do we go? *Health Place* 2009; **15:** 107–16.
11 Yang S, Kou SC, Lu F, Brownstein JS, Brooke N, Santillana M. Advances in using internet searches to track dengue. *PLoS Comput Biol* 2017; **13:** e1005607
12 Diggle PJ, Giorgi E. Model-based geostatistics for prevalence mapping in low-resource settings. *J Am Stat Assoc* 2016; **111:** 1096–120.